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THE BIOLOGY OF A WEEVIL (CYLINDROCOPTURUS EATONI BUCHANAN) INJURIOUS TO WESTERN YELLOW PINE REPRODUCTION

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SUBJECT—

INDEX NO.—

THE BIOLOGY OF A WEEVIL (CYLINDROCOPTURUS EATONI BUCHANAN) INJURIOUS TO WESTERN YELLOW PINE REPRODUCTION

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Although incidental notes have been made from time to time on the activities of various insects attacking reproduction in the pine forests of northeastern California, there are few published accounts of the life histories of the less obvious species. As a contribution to the knowledge of one of these minor insects there is presented in this paper some results of biological studies and experimental control tests on a recently described weevil (Cylindrocopturus eatoni Buchanan), lately found to be destructive to forest plantings of Pinus ponderosa Lawson and Pinus jeffreyi Greville and Balfour.

The forest plantations in northern California are unique in that they are largely confined to brushfield areas that generally have a dense cover of manzanita (Arctostaphylos spp.) and snow brush (Ceanothus spp.). Before stocking these areas, it is necessary to clear trails through the brush with heavy motorized equipment so as to provide cleared strips on which to plant the trees. The cost of preparing the ground added to the cost of growing and planting the stock may necessitate an expenditure of between $18 and $30 per thousand trees. The investment to reforest brushfield areas is therefore considerable. In certain areas it has been found that Cylindrocopturus eatoni can be a critical factor in determining the success or failure of pine plantings, and it may be considered a potential threat to other areas in which damage has not yet been observed. The fact that it has not been reported previously as a pest is probably due to the comparative recency of planting work

in the California pine region, and the inconspicuousness of damage in natural forest stands.

IDENTITY AND DISTRIBUTION.— The insect is a native species belonging to the family Curculionidae, subfamily Curculioninae. The genus Cylindrocopturus Heller is represented in North America by approximately 30 described species (Leng, 1920); however, the group is greatly in need of taxonomic study and revision, for the validity of various species is questioned by many authorities (Van Dyke, 1930). Few of the weevils belonging to this genus have been previously reported to be of economic importance.

The species under consideration in this paper was formerly considered to be one of a widely variable group of weevils passing under the name Cylindrocopturus longulus Leconte. However, biological studies indicated that perhaps some justification existed for designating it as a separate species, and as such it has been recently described by Buchanan (1940) under the name Cylindrocopturus eatoni. According to the authority this species belongs near the southwestern species C. obscurellus Casey, formerly placed as a synonym of C. longulus, but now considered distinct.

The distribution of C. eatoni is not well known. From the meager records available in the files of the Forest Insect Laboratory at Berkeley, Calif., the indications are that it is indigenous to the Lassen, Modoc, and Shasta National Forests in California where it occurs sporadically infesting reproduction in natural forest stands. Specimens in the U. S. National Museum, taken by H. E. Burke at Yreka, Calif., are reported to be this species. An examination of specimens in the collection of the Berkeley Forest Insect Laboratory shows that the species has also been taken at Placerville, Calif.

INJURY.-- The weevil causes damage in both the adult and the larval stages to young trees generally between one and three feet in height. The adult feeds on the needles of the host where it chews through the epidermal layer and devours the tissue beneath and peripheral to the hole through which the beak is inserted. The characteristic feeding puncture or feeding spot, about 1 mm. in diameter, turns brown after a short period and is readily discernible against the green background of the surrounding surface. Only in unusual cases are the feeding spots on the foliage sufficiently numerous to cause the death of the entire tree. Frequently, however, heavy feeding on the needles and young twigs may cause the flagging of individual shoots.

The feeding of the larvae in the stem and twigs of the host is far more serious than that of the adult weevil on the foliage, since it usually results in the death of the plant. The first indications of injury appear in late summer when the needles of infested trees begin to yellow and turn brown. Death of the foliage occurs progressively from the top downward and by the middle of October most of the needles are red. Death is effected through the destruction by the larvae of the phloem and cambium regions, thus cutting off conduction and exposing the wood to invasion by fungi. In the stem and larger twigs the grubs also riddle the outer wood, but in the smaller twigs they mine along the pith. Light attacks often result in the killing of a patch of tissue here and there on the stem, but the larvae seldom mature in these areas unless the tree dies. Frequently a seedling may be topkilled, the leader and upper branches being infested and the lower branches remaining green. This results in the formation of a scrubby individual of poor form, incapable of making good growth.

The only known natural hosts of the weevil are ponderosa and Jeffrey pine. It was found, by experimentally forcing attacks on other tree species, that the insect can kill seedlings of both sugar pine (Pinus lambertiana Douglas) and Douglas fir (Pseudotsuga taxifolia Britton), although white fir (Abies concolor Lindley and Gordon) did not appear to be susceptible to injury. There is no evidence, however, that the species can complete its life cycle in any of the last-named hosts, nor has it been collected from them under natural conditions.

LIFE HISTORY AND HABITS.-- The life cycle of Cylindrocopturus eatoni, and the more important types of damage it causes is depicted diagrammatically in Plate I.

The eggs of the weevil are minute pear-shaped bodies, approximately 0.48 mm. in length by 0.30 mm. in width. They are smooth on the surface, and when first deposited are translucent, but later become white. Each egg is placed singly in a small cavity excavated by the female in the outer cortex of the twigs or stem of the host. The eggs are very difficult to discern since they are located in living tissue interspersed with small droplets of resin; however, oviposition injury is usually denoted by the globules of resin formed on the surface of the bark at each point where a puncture is made. Egg laying begins during the middle of June and is completed early in July. The incubation period is probably of about two weeks duration. The eggs begin to hatch during the second week in July.

The larva is legless, about 3.5 mm. in length when fully grown. The head is light brown in color with darker areas on either side having the appearance of eyespots. The general color of the body varies from white in the younger stages to cream-colored in the mature larva. Upon hatching, the

larvae chew their way through the cortical tissue and phloem, making small irregular galleries filled with brown resinous frass. As the larvae mature the mines cross and run together with the result that eventually the entire area between the wood and the outer bark layer is completely destroyed. In the larger twigs and stem the greater part of the brood works into the outer layers of wood to pupate, although some of the larvae construct pupal chambers between the bark and the wood, particularly in parts of the stem where the bark is comparatively thick. In the smaller twigs the larvae mine into the pith.

Measurements of head capsule widths on 150 larvae collected at random from infested seedlings from July to October, had a frequency distribution which when plotted formed a triple-peaked curve. A frequency distribution of this type indicates three larval instars. Larvae in the first instar occur chiefly during the month of July, while second instar larvae are found in August. By mid-September the weevil population is comprised predominantly of larvae in the third and final instar which overwinter in the pupal chambers.

The pupa is cream-colored in appearance and is generally slightly larger than the adult weevil, averaging 3 mm. in length. Pupation takes place in a cell formed by the larva at the end of the gallery in the host plant. The greater part of the brood pupates between the third week in April and the third week in May. The pupal period is generally one month in duration, but after transformation occurs the new adults rest in the pupal chambers for an additional week before emerging.

The adult weevil is a small, compact insect about 2.6 mm. in length by 1.1 mm. in width, clothed with dark and light scales which give it a gray appearance. The color pattern above is formed by white scales interspersed

against a cupreous background. The underside is generally white, although a few dark scales may appear on the sides of the thorax. The sexes may be separated on the basis of external characters, the most reliable of which is the median impression of the first visible abdominal sternite. In the males this sternite is strongly impressed in the center, whereas in the females it is convex or only slightly flattened.

Emergence of the adults begins during the last week in May and peaks during mid-June. By mid-July comparatively few weevils may be found. The longevity of the adults is not definitely known, but in the present study living weevils of the attacking generation have never been found after the first week in August. However, there is reason to believe that a small number of weevils develop to the adult stage from eggs laid early in the summer, for callow adults have been found in the pupal chambers late in September. Overwintering adults outside the pupal chambers have not been observed.

The adults are active flyers and are also extremely agile in moving about over the twigs and needles of the host. They feed at first on the mesophyll tissue of the needles, making the characteristic feeding punctures already described, but later they feed on young bark of newly formed twigs, excavating feeding pits in the cortex in much the same manner as in the needles. Mating occurs shortly after the weevils emerge, the males pairing with the females on the needles or twigs where the females may be resting or feeding. The indications are that there is a preoviposition period of from two to three weeks for this insect, since emergence and mating occur early in June, but eggs are not commonly found until the first of July.

CONCENTRATION OF BROOD.-- The brood is usually found in all woody parts of the host above ground, but the infestation frequently extends into the rootstock an inch or two below the soil surface. In experimental rearings where stems, rootstocks and twigs of twenty infested trees were segregated, it was found that for the same volume of wood nearly two and one half times as many weevils emerged from the stems as from the twigs. Emergence from the rootstocks was about one-tenth that from the tops.

NATURAL ENEMIES.-- Nine species of native hymenopterons, identified by specialists of the Bureau of Entomology and Plant Quarantine, and believed to be parasites of Cylindrocopturus eatoni, have been recovered in the two seasons' rearings. They are listed as follows:

Braconidae	Urosigalphus pini Cushman[1] Microbracon pini Muesebeck[1]
Eulophidae	Euderus subopaca (Gahan)[2] Tetrastichus sp. near malacosomae Girault[2]
Eurytomidae	Eurytoma tomici Ashmead[2]
Ichneumonidae	Calliephalialtes comstockii (Cresson)[3]
Pteromalidae	Rhopalicus pulchripennis (Crawford)[2]
Scelionidae	Telenomus sp. near chrysopae Ashmead[1]
Trichogrammatidae	Zagella sp.[2]

All the species listed above, excepting Rhopalicus pulchripennis and Eurytoma tomici, were reared out in cages containing weevil infested material, thus the parasitic relationship to the weevil is not conclusively established. The two last named species were both reared individually from the host larvae. Throughout the rearing work R. pulchripennis was the species most often recovered.

1. Determined by C. F. W. Muesebeck.
2. Determined by A. B. Gahan.
3. Determined by R. A. Cushman.

occurring four times as frequently as all the other species combined. It is quite likely that under natural forest conditions parasites play a major part in keeping the weevil in check.

The larvae of a clerid were also found preying upon the weevil larvae. One adult, recovered from the rearing cages, was identified as Enoclerus moestus (Klug). This predator was not commonly encountered in the field, and it is doubtful if it is abundant enough to be significant in keeping down the weevil population.

FUNGUS ASSOCIATION.[4] -- A common lumber stain, Hormiscium gelatinosum Hedge., is almost invariably associated with the weevil. It has been cultured from various parts of infested trees as well as from different stages of the insect. Tests made during 1939 and 1940 indicate that the fungus is not pathogenic by itself, but follows generally where the weevil attacks the tree.

CONTROL.-- Under natural forest conditions the degree of damage caused by the weevil to the younger age classes of trees is probably not great enough to warrant control. However, in plantations (Fig. 1) where trees have been established at a considerable expense, some form of protection is justifiable. Where, for example, 70 to 90 per cent of the original stock is killed over a period of two or three years, as happened in parts of the brushfield plantings at Big Springs, Lassen National Forest, California, adequate control measures are badly needed.

In the course of this study two methods of artificial control were tested: (1) reduction of the weevil population through the eradication of infested trees; and (2) the use of concentrated sprays to prevent attack. Control

4. The information included in this section is taken from unpublished reports of investigations made by C. T. Rumbold and J. L. Mielke, Bureau of Plant Industry, United States Department of Agriculture.

through reduction of the weevil population was attempted in the Big Springs plantation, where with the help of CCC labor, all infested trees were pulled and burned, prior to the emergence of the 1939 brood. In spite of this work, however, 10 per cent of the remaining trees died by the fall of 1940. Presumably, the ineffectiveness of this method was due to a large population of weevils emerging from naturally infested stock in the surrounding forest.

Lead arsenate and cryolite, applied in the form of concentrated sprays after the manner reported by Potts (1940), were tested against the weevil under both laboratory and field conditions. These materials were sprayed on uninjured ponderosa pine trees early in June prior to the emergence of the 1939 brood, in order to prevent feeding or oviposition injury. The lead arsenate spray mixture consisted of 1 part acid lead arsenate, 0.25 part light oil, 0.03 part wetting agent and 10 parts water. The cryolite spray was made up of one part synthetic cryolite, 0.01 part wetting agent and 2 parts water. A dosage of approximately one-tenth of a pint per tree was sufficient to cover throughly the needles, twigs and stem. The apparatus for applying these materials consisted of a quart-size paint spray gun, compressed air for which was furnished from a portable, gasoline-powered compressor. In the laboratory tests a series of 10 potted seedlings were treated with each chemical. Five of each series were caged and exposed to the attacks of several hundred weevils placed in the cages. The remaining 5 seedlings were left uncaged to test the effects of the chemical alone on the foliage. In the field tests, trees growing in Big Springs brushfield were used, with 10 instead of 5 seedlings serving as the unit for each test.

A summary of the results of this work is given in table 1. It was

Insert Table 1.

found that both insecticides were 100 per cent effective in preventing weevil attack, while unsprayed check trees were killed in every case. Feeding punctures were reduced from an average of 14 per linear inch of needle on the check trees to 0.2 per linear inch on the sprayed trees. No deleterious effects attributable to the chemical were evident on any of the treated trees five months after the spray was applied, in spite of the fact that heavy deposits were secured in every case. Although these tests do not show that either chemical is superior to the other, the lead arsenate spray mixture is recommended because of better weathering qualities, and the fact that greater coverage can be secured for the same quantity of insecticide.

SUMMARY.-- The weevil, Cylindrocopturus eatoni Buchanan, is a newly described species native to northeastern California, where it has recently been found to be injurious to brushfield plantings of ponderosa and Jeffrey pine. Injury is caused chiefly by the mining of the larvae within the cortical region of the host which results in the death of the tree. Minor damage is caused by the feeding of the adults on pine needles. The insect has a one year life cycle. The winter is passed in the larval stage, pupation occurs in the spring and the adults emerge during June. The weevils mate and the females deposit their eggs in the stems and twigs of small trees early in July. Larval development from the egg and subsequent feeding within the cortical area is accompanied by the death of the tree. By the time the latter is completely brown the larvae are mature.

Experiments with concentrated sprays of both lead arsenate and cryolite showed that both these chemicals will effectively prevent injury to trees exposed to attack by the weevils.

Table 1. - Summary of tests with concentrated sprays to prevent damage to pine seedlings by Cylindrocopturus eatoni.

Treatment	Trees Treated	Weevils Caged on Each Tree	Tree Mortality* Number	Tree Mortality* Per Cent
Tests with Potted Trees				
Lead Arsenate	5	400	0	0
	5	0	0	0
Synthetic Cryolite	5	300	0	0
	5	0	0	0
Check (untreated)	5	300	5	100
Tests with Trees Growing in Big Springs Brushfield				
Lead Arsenate	10	300	0	0
	10	0	0	0
Synthetic Cryolite	10	250	0	0
	10	0	0	0
Check (untreated)	10	200	10	100

*Five months after treatment.

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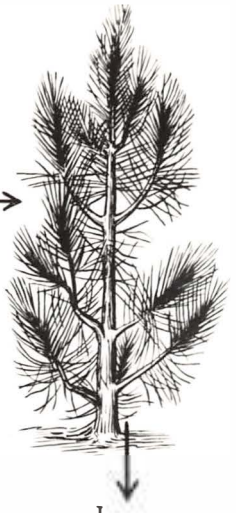
Potts, S. F. 1940 Concentrated sprays mixtures and their application by ground and aerial equipment as compared with standard spraying and dusting methods. U. S. Department of Agriculture, Bur. Entomology and Plant Quarantine, E-508.(mimeo)

Van Dyke, E. C. 1930 New Rhynchophora (Coleoptera) from western North America. Pan Pacific Ent. 6(4):149-165.

Plate I

LIFE CYCLE of CYLINDROCOPTURUS EATONI BUCH. in PONDEROSA AND JEFFREY PINE

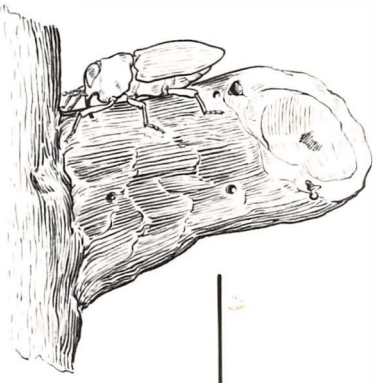
JUNE
Weevils emerge from infested trees, mate, and attack living seedlings.



Emergence holes in abandoned seedling.

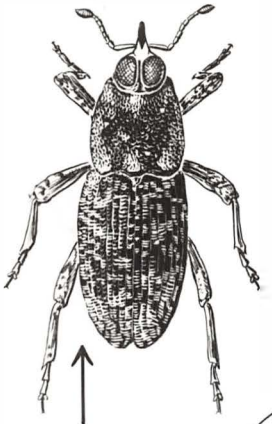
Feeding punctures in pine needles.

JULY
Females lay eggs in cortex of twigs and stem.



AUGUST-MARCH
Larvae mine in the phloem and outer wood; over-wintering in pupal cells.

APRIL-MID MAY
Pupation takes place in cell in the wood of infested tree.



LATE MAY
Pupae transform to the adult stage.

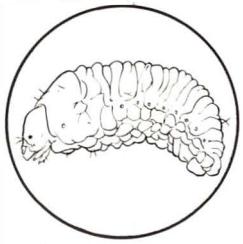


Figure 1.-- Section of Big Springs brushfield, Lassen National Forest, California, showing row of planted ponderosa pine seedlings of the size usually attacked by the weevil. Caged seedlings in background are part of series used in tests with concentrated sprays.